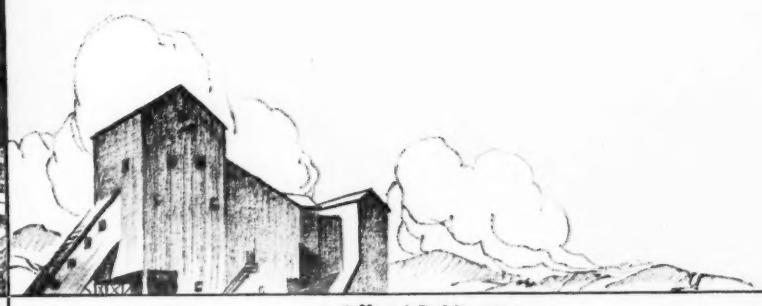
The CRUSHED STONE JOURNAL

In This Issue



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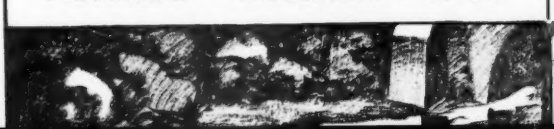

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The Crushed Stone Journal

Official Publication of the NATIONAL CRUSHED STONE ASSOCIATION

J. R. BOYD, Editor

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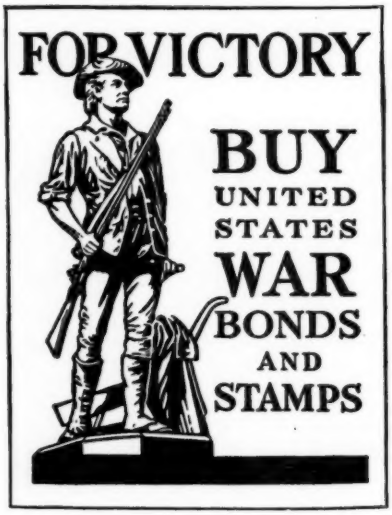

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Discussion of Concrete Mixture Design

By A. T. GOLDBECK
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National Crushed Stone Association.

• In the May-June, 1942, issue of the Crushed Stone Journal there was published a simple, but effective, method for designing workable concrete for any desired compressive strength, using any type of coarse aggregate. Facts which justify the use of that method are given in the present discussion.

THE following discussion was presented before the last annual meeting of the American Concrete Institute in criticism of Reports of two committees, namely, "Report of Committee 611, on the A. C. I. Manual of Concrete Inspection," issued as a special A. C. I. publication, July, 1941, and, also, "Report of Committee 613, Recommended Practice for the Design of Concrete Mixtures," A. C. I. Journal, January, 1942, Proceedings V. 38, page 193.

The reports above referred to call for the design of concrete on the basis of a specified maximum water-cement ratio, irrespective of the type and character of the coarse aggregate to be used and on the assumption that a given water-cement ratio alone controls the strength and durability of concrete. This method of design ignores the influence of the aggregate on the properties of the hardened concrete. It may well force the use of an aggregate which will not make durable concrete and may eliminate one that will; coarse aggregate does influence the strength and durability of concrete. The design methods proposed are incomplete and erroneously discriminate in favor of one type of coarse aggregate in a manner which is not justified by the facts.

This discussion will amplify the preliminary statement contained in the article by Messrs. Goldbeck and Gray on "Design of Concrete for Compressive Strength, Workability and Durability," appearing in the May-June, 1942, issue of the CRUSHED STONE JOURNAL.

Discussion before American Concrete Institute

A. T. GOLDBECK: The subject matter of the Section on Design of Mixes is built up on the basis of certain fundamental conceptions which will be examined in the present analysis. It is stated, "The first consideration in mix design should pertain to the cement paste, that is, it is necessary to select the type of cement to be used and the water-cement ratio." At the present time there are different classes of cement and for that matter there always have been cements of different characteristics and so naturally the characteristics of the cement must be considered. The conception that one must select a definite water-cement ratio is based on the assumption that a definite water-cement ratio controls both the strength and the durability of concrete.

The assumption that water-cement ratio controls the strength of the concrete is founded on the general water-cement ratio strength relationship originally stated by D. A. Abrams in his Bulletin 1 of the Lewis Institute. Concrete must be mixed to a given consistency or plasticity for a given type of structure so that it may be placed and finished properly in a manner such that uniformity and freedom from honeycomb will result. Under the conception of a constant water-cement ratio it very naturally follows that aggregates which are rough and angular will

require more paste than aggregates which are smooth and rounded, and, consequently, it further follows that under this conception of concrete design more cement must be used for angular, rough aggregates

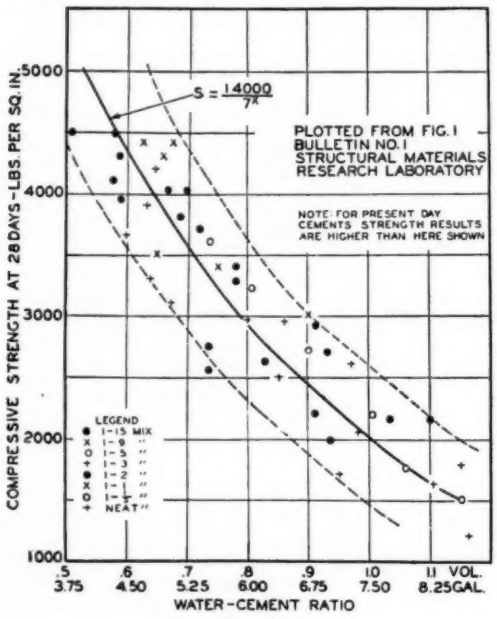

FIG. A

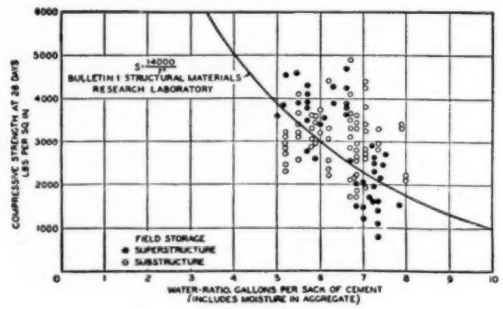

FIG. B

COMPRESSIVE STRENGTH—WATER-CEMENT RATIO RELATIONSHIP FROM FIELD SPECIMENS, PORTLAND CEMENT ASSN. BLDG., CHICAGO.

than for rounded, smooth aggregates, irrespective of what the final properties of these different concretes may be and entirely irrespective of the relative suitability of these respective concretes for the actual work they must perform after they are in the structure.

It becomes pertinent to inquire into the adequacy of such a conception of design to produce concrete having the desired strength and durability for the conditions under which it must serve. Years ago the admirable work done under the direction of Abrams at the Lewis Institute established the well known water-cement ratio compressive strength relationship. The average curve showing that relationship, appearing as Fig. 1 in Bulletin 1 of the Lewis Institute seems to show a very definite relationship indeed, especially when the entire curve is viewed, with water-ratios extending all the way from approximately 0.4 up to 4.0 by volume. But I wonder how many concrete technicians have stopped to think that, as a rule, they are concerned with only a very limited portion of that curve, that portion extending from 0.5 to 1.25 water-cement ratio. The curve is merely the average of a number of individual strength results and the significant portion is reproduced in Fig. A.

It will be seen from Fig. A that there is rather a wide deviation of the individual results from the average. For illustration, for a value of 6 gal. of water per sack of cement, the range of compressive strengths was from approximately 2300 up to 3600 psi., the top value being about 56 per cent higher than the low value. These are laboratory results obtained under very carefully controlled conditions and by expert technologists. The cement and aggregates were identical for all of the tests, but were mixed in different proportions. When different aggregates were used it is found that each aggregate may have a water-cement ratio strength relationship of its own, more or less parallel with a similar relationship shown by another combination of aggregates. To obtain a given strength with one set of aggregates, a given water-cement ratio must be used, but another water-cement ratio is necessary for another set of aggregates. Professor Abrams recognized this to be the case in his original design bulletin, for his first conclusion was, *"With given concrete materials and conditions of test* the quantity of mixing water used determines the strength of the concrete so long as the mix is of workable plasticity." Please note the words, "with given concrete materials." The fact is, that a general water-cement ratio strength relationship is merely the average of a number of such re'ationships which differ from one another depending upon the aggregates used and their combinations.

Actually, there are a number of factors which control the compressive strength of concrete of which the water-cement ratio, although of high importance,

TABLE A

Comparison of Concretes Made With a Limestone and a Siliceous Gravel

No. of Sacks	Gravel				Limestone				Stone-Gravel Strength Ratios
	b/bo	Gallons per Sack	Total Weight of Water	Strength Compressive Modulus of Rupture	b/bo	Gallons per Sack	Total Weight of Water	Strength Compressive Modulus of Rupture	
5	.709	6.53	272	3780 571	.703	7.25	302	3650 677	.965 1.19
6	.704	5.48	272	4390 655	.696	6.00	298	4520 720	1.03 1.10
7	.712	4.82	282	5140 707	.706	5.28	308	5440 825	1.06 1.17

is not the sole factor. One merely has to examine the water-cement ratio strength relationship curve obtained with concrete made in the field to be satisfied of the truth of that statement. In Fig. B is shown such a curve obtained on field concrete mixed and tested under expert supervision. The curve was published first in *Engineering News-Record*, V. 96, No. 17 and it applies to the concrete used in the construction of the present Portland Cement Association building in Chicago. Such a curve merely demonstrates the great difficulty of controlling all of the variables which affect the strength of concrete and it demonstrates the entire inadequacy of a given water-cement ratio as a means for controlling concrete strengths. Yet many a really superior coarse aggregate has been entirely eliminated from use, not by the application of the water-cement ratio strength relationship itself, but by an entire failure to realize its limitations. The relationship exists but it is a different relationship for different aggregates and different other conditions.

Let us be more specific by considering a comparison of two concretes, one made with a good grade of limestone and the other made with a good grade of siliceous gravel. Both materials were graded essentially alike and had a 1½ inch maximum size. Both materials were designed to have essentially the same workability. The comparison of these respective concretes is shown in Table A.

Table A shows that the limestone concretes were surely not inferior to the gravel concretes in compressive strengths and they certainly were superior

TABLE B

Effect of 100 Cycles of Freezing and Thawing on Concretes, Age 10 years

Cement Factor, 6.3 Sacks per Cu. Yd., Freezing at —10 to —20 F., Thawing at 70 F. in Water

No.	Coarse Aggregate	Water-Cement Ratio by Volume	Per Cent Loss in Weight	Permanent Expansion Inches per Inch No. x 10^{-6}	Per Cent Reduction in Modulus of Rupture
2	Stone	.79	0.0	114	51
33	Gravel	.79	0.1	295	77
5	Stone	.81	0.3	12	4
6	Gravel	.74	0.2	25	14
7	Stone	.81	0.1	87	40
8	Gravel	.75	0.0	321	66
13	Stone	.79	0.0	75	37
17	Gravel	.69	3.3	159	64
23	Stone	.78	0.2	134	61
24	Gravel	.71	0.0	273	61
117	Stone	.79	0.3	150	55
31	Gravel	.73	0.1	93	51

to the gravel concretes in beam strengths, in spite of higher water ratios being used in the limestone than in the gravel concretes. The cement factors were the same for both aggregates. Surely, the use of some arbitrarily selected water-cement ratio, on the assumption that it would give like strengths would not be warranted in this case and if these respective concretes were designed on that basis, more cement would be required for the limestone concrete than for the gravel concrete no matter whether it needed it or not. Were these two aggregates in competition a very grave injustice would be done and, in effect, a monopoly would be created for the gravel aggregate by the method of design suggested in the Manual.

Another of the concepts evidently used in the Manual in connection with design of concrete is that it is quite necessary to keep the water-cement ratio in the paste as low as possible, because thereby less shrinkage of the concrete results, and for the same reason it is stated that the paste content itself should be kept to a minimum. It is perfectly true that with a given cement content the higher the water-ratio, the higher will be the shrinkage. But consider the cases given above in Table A. In the first place, the difference in water-cement ratio is not great as between the stone and gravel concretes and, accordingly, the difference in shrinkage would not be great. Furthermore, amount of shrinkage is only one of the factors to be considered in connection with any deleterious effects shrinkage may have. Another important factor is the tensile resistance of the concrete. If concrete were unrestrained, shrinkage would produce no internal stress. If the concrete is restrained then shrinkage can produce internal tension. But it does not necessarily follow that increased shrinkage will produce increased cracking or even wider cracking, for the concrete having that increased shrinkage may be better able to withstand the tendency toward shrinkage because of its higher tensile resistance.

It is seen in the above examples that the limestone concrete had higher beam resistance than the gravel concrete. Beam resistance is at least a measure of tensile resistance. Accordingly, the stone concretes above cited, although possibly, but not assuredly, having a slightly greater tendency to shrink than the gravel concretes, at the same time have higher resistance to cracking due to that shrinkage. Thus, from the standpoint of possible deleterious effects from increased water-ratio, the slight difference in water-ratio as between stone and gravel concretes with the same cement factor is hardly worth a second thought.

Can this slight increase in water-ratio have a deleterious effect so far as lack of durability is concerned? It is true the paste will be just a little bit weaker and a little bit less dense, but only a little bit and there are factors which bring about lack of durability in concrete which far outweigh any slight differences in durability due to these rather inconsequential differences in water-cement ratio. By and large, it is very true that with the same aggregates a high water-cement ratio would produce weaker and less durable concrete than a low water-cement ratio and there can be no objection to the setting up of a definite maximum water-cement ratio for the purpose of attempting to control durability of concrete. But that is quite a different matter from the use of a definite water-cement ratio from which there can be no departure and because of which more cement must be used in one concrete than in another.

When different aggregates are used in concrete it is entirely possible to have a concrete of low water cement ratio showing less durability and higher volume change than concrete having a high water-cement ratio. In Table B are given some test results which will substantiate that statement.

All of the concretes in Table B were designed to have 6.3 sacks of cement per cu. yd. They are the concretes described in the National Crushed Stone Association Bulletin No. 7, "Investigations in the Proportioning of Concrete for Highways," September 1931. The broken beams from these concretes have been continuously stored in the moist room for the past ten years. From them slabs have been sawed 2 in. thick and 6 in. square. These slabs have been subjected to freezing and thawing tests up to 100 cycles, at the end of which the loss in weight was obtained as well as the permanent expansion of the specimens and likewise these slabs were tested for modulus of rupture. Time does not permit of a complete analysis of all of these data, but let it be pointed out that specimen No. 17 having the lowest water-cement ratio of all the concretes shown, has the highest percentage of loss in weight after 100 cycles of freezing and thawing and also shows next to the largest reduction in beam strength due to freezing and thawing. This concrete was made with a siliceous gravel from Texas. The failure from freezing and thawing was classed as a mortar failure. Concrete No. 5, made with trap rock, had the highest

water-cement ratio and it will be observed that this concrete suffered very little reduction in slab strength after 100 cycles of freezing and thawing and showed very little permanent expansion due to freezing, the type of failure being classified as a mortar failure.

The range of water-ratios shown in the table is representative of the range to be expected in practice for highway concretes. A study of this table will demonstrate that the effect of freezing and thawing on these concretes, whether that effect be reduction in modulus of rupture, the production of permanent expansion, or loss of weight, is not a relationship consistent with the values for water-cement ratio. Quite evidently there are other factors acting to bring about deterioration of the concrete which are more significant than the slight difference in water-cement ratio necessary for equal consistency in the stone or gravel concretes. Yet, the method of design in the manual lays the greatest stress on the water-cement ratio of the cement paste to the utter neglect of more important factors controlling the durability of the concrete.

Thus, again, it is emphasized that if concrete is to be designed for a structure on the basis of that concrete being capable of serving in that particular structure over long periods of time, something more is needed than the mere setting up of some arbitrary water-cement ratio as a means for controlling durability and then manipulating the proportions for the purpose of obtaining plasticity. The fact that an arbitrary selection of water-cement ratio irrespective of other influencing factors does not necessarily lead to the same strength or to the same durability does not mean that the water-cement ratio strength relationship does not have value. That is far from the case. It does have value, but it should not be used as a fixed value in such a way that it creates a monopoly for one type of aggregate and thereby excludes aggregates which may produce a more durable structure by a very wide margin. Thus, the use of the water-cement ratio method of design suggested in the Manual for the purpose of obtaining durable concrete of sufficient strength not infrequently defeats its own purpose. It may actually prevent the use of the most suitable aggregate.

The question now arises, What method of design should be used in lieu of the one indicated in the Manual against which such serious objection is here raised? First, the most certain method is by the use of thorough investigation of the aggregates and concrete using every known test which may have a bearing on the particular problem in hand. It is not enough to decide on some arbitrary water-cement ratio and then merely design the concrete for proper workability. There is something far more important than mere ability to place the concrete properly. That something is the ability of the concrete to resist whatever forces and actions it may be subjected to after it is in the structure. The tests should simulate those actions and they may include freezing and thawing, expansion and contraction due to moisture and temperature, chemical effects and any others that may be important in connection with the particular structure under consideration. Beam tests should replace compression tests for road slabs.

I realize that this is a big order and frequently cannot be undertaken except in the very largest of structures and so the question arises as to what is the next best thing to do.

1. I would propose that the water-cement ratio relationship be recognized to the extent of setting up maximum values for water-cement ratio, depending on the exposure conditions of the structure.

2. With a water-ratio not in excess of that required for the desired durability and consistency a cement factor should be used which will give the required strength. This same cement factor should be used in designing concrete for different aggregates. This will require a varying water-cement ratio as well as a varying sand factor to maintain the desired consistency. In no case should the desired maximum water-cement ratio be exceeded.

The advantages of this method are:

1. A definite cement factor will be required and this is of advantage in safeguarding the quality of the concrete mixed to a given consistency.

2. The water-cement ratio principle is recognized, but not to such an extreme extent that competition between different kinds of coarse aggregates is impossible.

3. The engineer is given a wider choice of aggregates, some of which may make superior concrete, but which are virtually eliminated if a single, average water-cement relation is followed blindly.

The method suggested is not new. It is recognized and used by some very important government departments and state highway departments and is the basis for Alternate B specifications in the Joint Committee Report. Its philosophy differs from that of the present chapter on design in the Manual. It is impossible merely to revise the present chapter on Design of Mixes in the Manual by the use of slight

revisions; it must be re-written. There is little use at the moment in bothering with the detailed wording necessary to revise the Manual. That requires quiet study. The important thing now is to recognize that the present method of design is inadequate and does not lead to the best and most durable concrete.

The last portion of this discussion before the A. C. I. covers material previously published in the May-June, 1942, issue of the CRUSHED STONE JOURNAL, and hence has not been repeated herein.

(End of Discussion Before American Concrete Institute)

Shrinkage of Concrete

Since the preceding discussion was presented before the American Concrete Institute, additional investigations have been made in the laboratory of the National Crushed Stone Association which have a bearing on the design of concrete mixtures. The method of concrete design described by Messrs. Goldbeck and Gray in the May-June, 1942, issue of the CRUSHED STONE JOURNAL[1] results in sand contents which vary depending on the size and character of the coarse aggregate, on the gradation of the sand and the paste content. Crushed stone, as a rule, has a somewhat higher percentage of voids than gravel and, hence, according to the method of design before mentioned, more sand and likewise somewhat more water must be used for crushed stone than for gravel concrete to obtain the necessary workability. Very naturally the question arises as to what might be the effect of this increased amount of sand and water on the shrinkage of the concrete. The following tests, made by Mr. Gray under the direction of the writer throw light on this subject and may be divided into two parts:

(a) Shrinkage or settlement of concrete while setting.
(b) Shrinkage of concrete due to drying.

(a) Shrinkage or Settlement of Concrete While Setting

The main purpose of the present tests was to determine how much shrinkage or settlement of con-

[1] Also in Bulletin 11 of the N. C. S. A. and in *Engineering News-Record* for November 5, 1942.

TABLE C

Settlement or Shrinkage of Wet Concrete During First 24 Hours

Nominal cement factor	7	7	7	7	5	5	5	5
Nominal slump	3	3	3	3	6	6	6	6
Type of coarse aggregate	Gravel		Stone		Gravel		Stone	
Max. size coarse aggregate	¾	2	¾	2	¾	2	¾	2
	TEST RESULTS							
Slump	3	3	3	3	6¼	6½	7	6
W/C (Water-Cement ratio by volume)	0.70	0.63	0.78	0.68	1.05	0.90	1.18	0.98
Total water, gal. per cu. yd.	36.6	33.0	40.8	35.6	39.2	33.9	44.0	36.9
Density: Wt. per cu. ft., lb.								
1 cu. ft. measure	145.4	148.3	146.2	149.8	143.2	146.5	143.7	147.9
Ave. of 5 cylinders	146.3	149.1	147.9	151.0	144.5	147.9	145.2	148.6
Percent linear or volumetric 1.	0.42	0.36	0.79	0.34	1.25	0.53	1.09	0.76
shrinkage in 6 x 12 in. 2.	0.75	0.37	0.81	0.44	1.05	0.40	1.38	0.80
cylinders after 24 hr. 3.	0.70	0.29	0.74	0.40	1.33	0.48	1.18	0.62
4.	0.57	0.39	0.60	0.46	1.48	0.64	1.11	0.75
5.	0.58	0.37	0.68	0.50	1.43	0.57	1.23	0.52
Ave.	0.60	0.36	0.72	0.43	1.31	0.52	1.20	0.69
Cement factor, based on								
Solid volume of materials	6.98	6.98	6.97	6.98	4.98	5.02	4.97	5.02
Yield test, cu. ft. measure	6.82	6.82	6.84	6.88	4.88	4.94	4.88	4.94
Yield test, ave. of 5 cylinders	6.86	6.86	6.92	6.94	4.92	4.98	4.93	4.97
Set concrete[2]	7.02	7.01	7.02	7.01	5.05	5.05	5.03	5.05
Percent sand by solid volume	37	30	43	36	39	33	45	38

The same sand was used in all mixes; its fineness modulus was 2.36.

[2] Computed from cement factor based on solid volume of materials and shrinkage value.

TABLE D

Shrinkage of Gravel and Stone Concretes Due to 5 Months Air Drying after 28 Days Moist Curing, Based on Initial Measurements Taken at 7 Days

	Gravel				Stone			
Cement, 5 Sacks								
Percent Sand	34	36	38	40	38	40	42	44
W/C, volume	.84	.87	.91	.92	.93	.94	.97	.97
Slump	3.1	2.8	3.5	3.4	3.8	3.1	3.1	2.8
Contraction, in. per in.	.00045	.00050	.00051	.00053	.00041	.00045	.00050	.00045
Cement, 6 Sacks								
Percent Sand	33	35	37	39	37	39	41	43
W/C, volume	.72	.73	.74	.76	.77	.78	.80	.82
Slump	3.8	3.2	3.2	3.2	3.8	3.4	3.6	3.0
Contraction, in. per in.	.00037	.00043	.00044	.00047	.00034	.00040	.00038	.0039
Cement, 7 Sacks								
Percent Sand	32	34	36	38	36	38	40	42
W/C, volume	.59	.64	.64	.65	.69	.70	.70	.71
Slump	3.6	3.5	3.0	3.6	3.4	3.4	3.2	3.4
Contraction, in. per in.	.00044	.00044	.00047	.00052	.00037	.00040	.00045	.00047

crete occurs during the first 24 hours while it is setting. Incidentally, information was obtained on the density of molded specimens in comparison with the density of fresh concrete as obtained by unit weight tests and also a comparison was made of the cement factors determined under different conditions.

Test Procedure

The test procedure consisted in making eight batches of concrete and determining the weight per cubic foot by standard A. S. T. M. methods and also from the weight of standard 6 x 12 in. cylinders. After 24 hours the top cover plates were removed from the 6 x 12 in. specimens and the amount of shrinkage was determined by filling, with modelling clay, the space above the specimen caused by settlement, then removing the clay from the specimen, weighing it and thus determining its volume. The density of the clay had previously been obtained.

In Table C are given the characteristics of the concrete mixes and the test results.

Discussion of Results

The shrinkage or settlement of gravel concrete during the first 24 hours is compared with that of stone concrete using two maximum sizes of coarse aggregate ¾ in. and 2 in. and two combinations of consistency and cement factor, namely, 3-inch slump and 7 sacks of cement and 6-inch slump with 5 sacks of cement.

In general the following trends are noted:

1. There is less settlement or initial shrinkage with 2 in. than with ¾ in. aggregate.
2. There is somewhat more settlement with stone concrete than with gravel concrete, but the difference is small.
3. There is more settlement with the 6-inch slump, 5 sack concrete than with the 3-inch slump, 7 sack concrete.

The question of immediate concern is the settlement of the concrete as influenced by the coarse aggregate. Re-arranged, the results expressed as percentage of settlement are as follows:

3-inch Slump, 7 sacks

¾ in. stone, 0.72%	¾ in. gravel, 0.60%
2 in. stone, 0.43%	2 in. gravel, 0.36%

6-inch Slump, 5 sacks

¾ in. stone, 1.20%	¾ in. gravel, 1.31%
2 in. stone, 0.69%	2 in. gravel, 0.52%

In a ten-foot column, for illustration, in which 7 sack, 3 in. slump, ¾ in. aggregate concrete would be appropriate, gravel concrete would settle 0.60% of 120 in. = 0.72 in.; stone concrete would settle 0.72% of 120 in. = 0.86 in. But both concretes are unhard-

ened during the settlement, so the fact that one settles only 0.14 in. in 10 feet more than the other has no particular significance. In any event, concreting of the floor above would not proceed until complete settlement in the columns had taken place. Evidently then this slight difference in settlement of the respective concretes in their unhardened condition is of no importance.

Apparently the initial settlement of the soft concrete is controlled by the size of coarse aggregate, the slump and the cement factor and the effects produced by shape of coarse aggregate are rather minor as compared with the effects of these other factors.

A study of that part of Table C dealing with the calculated cement factor will be particularly of interest to concrete technicians. The settlement of the concrete slightly increases the cement factor above that in the fresh concrete.

(*b*) *Shrinkage of Concretes Due to Drying.*

After the concrete has hardened, volume change takes place due to change in moisture content and also due to thermal changes. To study the shrinkage due to drying out, tests were made on a number of samples of concrete made of Potomac River gravel compared with Martinsburg limestone. The specimens were made with different cement factors, 5, 6 and 7 sacks per cu. yd., different sand factors, and different water-cement ratios as indicated in Table D.

Measurements for shrinkage were made with a 10 in. Whittemore strain gage. These measurements show no great difference between the stone and gravel concretes despite the greater sand and water contents in the stone concretes. There is no need of analyzing the results in detail. There simply isn't enough difference in shrinkage due to the effect of the aggregate on the concrete proportions to make any practical difference in the characteristics of the final concretes. There should be very little difference in shrinkage stresses and therefore little difference in cracking due to this cause if all other contributing factors are equal.

The present tests are important because they show that the higher sand and water contents required in stone concrete as compared with those in gravel concrete, do not significantly affect the relative 24 hour settlement or subsequent shrinkage of concretes made with these respective materials, thus still further justifying confidence in the concrete design method described in the May-June, 1942, CRUSHED STONE JOURNAL.

Two-Thirds of 1941 Transportation Taxes Were Paid by Highway Users

MOTOR vehicle owners paid approximately two-thirds of all taxes assessed against transportation agencies in 1941 according to the first annual report of the Board (Transportation) of Investigation and Research to the President and Congress. Taxes paid by transportation agencies last year amounted to more than three billion dollars of which more than two billion was paid by highway users, nearly 600 million dollars by railroads and the balance by water, pipeline and air carriers, the report shows.

The turning of peace-time transportation surpluses into war-time shortages is not expected to prevent return after the war in intensified form of the old problems of "over supply and destructive competition," according to the Board.

The report comments on the 130 million acres of land granted by the Federal government and 49 million acres granted by state and local governments to the railroads and Federal expenditures on waterways that amount to nearly two billion dollars up to June 30, 1940. During the 1921-1940 period about 39 billion dollars of public funds, much of which was derived from special motor vehicle taxes, were spent on roads and streets.

The Board, organized a year ago under authority of the Transportation Act of 1940, expects to file an additional report and recommendations on interterritorial freight rates in January, 1943. Its findings on public aids to transportation and taxation are scheduled to be announced during the 1943 fiscal year.

Highway Restrictions Hit Treasury

UNCLE Sam's Treasury is beginning to feel the impact of war-time restrictions of motor vehicle sales and use. Latest Internal Revenue Department figures show the following comparisons of September automotive taxes this year with 1941:

	1942	1941
Automobile trucks	$ 484,511	$ 852,828
Automobiles and motorcycles	338,420	5,002,003
Automobile parts and accessories	1,460,229	1,417,599
Tires and inner tubes	953,491	3,241,553
Lubricating oils	2,933,417	3,576,516
Gasoline	29,204,878	33,854,755

Public Works Planning in War and Peace[1]

By MAJOR GENERAL PHILIP B. FLEMING
Administrator, Federal Works Agency

• A great program of public works, federal and local, formulated under federal leadership, is one of the major means available to maintain our national income, provide full employment and absorb the products of industry. How this can be accomplished is interestingly discussed by Major General Fleming in the following article.

ONE hundred and thirty-nine years ago this month the Stars and Stripes were raised at New Orleans to signalize the passing of European sovereignty from the Mississippi Valley. The Louisiana Purchase was a most striking example of the value of foresighted national planning and leadership. It doubled our area, and by providing economic opportunity through free land, provided a strong foundation for our young and struggling experiment in democracy. Here, in the industrial capital of the Purchase, it seems fitting to again turn our thoughts to the value of leadership in foresight and planning, so well illustrated in the career of Thomas Jefferson.

I also recall an early example which occurred here of successful federal-local cooperation in the planning and execution of public works by which the nation has been developed. In the '50's the Mississippi River, which had made the city, was destroying it by filling the harbor with silt. Islands, more than a mile long had formed in the channel and were blocking access. They were increasing in size daily and it appeared that St. Louis was doomed. But a captain of the United States Corps of Engineers developed a plan to divert the current to the Missouri side and thus wash away the islands. He had only $50,000 for the work, but it was so skillfully applied that the silting was arrested and the islands greatly reduced. The city raised the funds necessary to complete the project and the commerce of St. Louis was saved. The name of that Captain of Engineers is known to history as Robert E. Lee.

We are engaged in a desperate war to preserve our national existence, our way of life and our standards of living. But a mere military victory over Hitler and Japan will not be sufficient. Democracy must win the peace as well as the war. To win the peace requires planning to meet the situation as of the prospective armistice. It may come suddenly and find us unprepared as in 1918. I am not attempting to prophesy when it will come. I say only that it will come and that now is not too soon to begin planning for it. Adequate planning will be an aid to our soldiers and sailors, whose victory will not be sufficient solace if they return to a country in the throes of post war depression and to a vain search for the means of livelihood in competition with millions of workers whose employment in war industries will have ceased.

Measures to continue full employment for war workers and to provide it for discharged veterans must be devised and so fully developed before the armistice as to be then promptly placed in effect. This is a difficult task but it can and must be accomplished.

A great program of public works, federal and local, formulated under federal leadership, is one of the major means available to maintain our national income, provide full employment and absorb the products of industry. Such a program is also indispensable to provide public works needed for the development of the nation.

An adequate program cannot be improvised. It should be formulated long in advance so that it can be submitted to the President and Congress to be coordinated with other devices to facilitate the nation's conversion from war to peace in an over-all plan to sustain and develop the nation.

The war has brought about basic changes in our economy. Industries have been established in new locations. Migrations of workers have followed them. Our manufacturing plant capacity has been substantially increased, facilities for air transportation have been multiplied many fold. A program for public works must take account of these changes and their effects.

Our system is founded on private enterprise. The directors of business, upon whom we primarily depend for the satisfaction of most of our material

[1] Before the Annual Business Meeting of the American Association of State Highway Officials, Hotel Statler, St. Louis, Missouri, Monday, December 7, 1942.

needs, must know long in advance the plans of Government, for post war reconstruction in order that their own plans may conform. The program of public works to be adopted is one of the bases of business planning.

Our States and cities and other local public agencies are responsible for public works locally needed. Planning and programming them must precede their construction. The works to be provided by the nation and the nature and degree of aid which the nation intends to provide for local agencies must be known to them in advance.

Congress also must be informed of the recommendations of the Federal agencies responsible for the preparation of six-year programs of public works so that it may review these programs in the light of its knowledge of the nation's needs and determine how and to what extent the nation will finance accomplishment. Such legislation will require estimates of the cost of projects. Such estimates must be based on plans and specifications for each project, federal or local, included in the comprehensive program.

Neglect to plan and program in due season, procrastination until we are in the midst of a crisis, wastes immense sums and causes cruel sacrifices of human values. This is clearly apparent from our experience of the '30's when depression and vast unemployment were upon us.

In 1933 Congress and the President set up the Federal Emergency Administration of Public Works, soon dubbed PWA, and gave it three billion dollars to provide employment quickly. PWA was directed to prepare a comprehensive program of public works to include federal and non-federal projects to furnish the employment. The directions of the Act thus were in conflict since it was impossible both to program public works and to provide employment quickly. The necessary organization did not exist and had to be assembled. Non-federal projects for its processing were lacking and had to be selected, developed and authorized by local legislation. Even federal projects ready for construction were few. It was not possible in the circumstances to prepare a program—that is, to schedule projects in proper relation to the resources in labor and materials, and to their importance to the nation and of the locality of the site. The test of acceptance by PWA necessarily became the degree of readiness of projects for advertisement and contract. Few were ready or could be made ready. Eighteen months elapsed before 100,000 of the 10,000,000 or more unemployed could be put to work on PWA projects. What happened? To keep men and women from starving the President in November, 1933, set up a force account agency, the Civil Works Administration, and allotted to it $400,000,000 of PWA money to provide employment on such projects as could be quickly improvised. In four months CWA had spent its allotment. It sustained 4,000,000 of our people for that period; but few public works of permanent value resulted.

This $400,000,000 was only a small part of the price paid by the American people for a lesson in the economy of advance planning. By June 30, 1941, more than eleven billion additional dollars had been expended for work relief under Emergency Relief Appropriation Acts. Of this sum, sponsors contributed about 20 per cent. Many thousands of miles of roads and thousands of useful and needed structures were provided by the millions of WPA workers who were sustained by this expenditure. I regard the WPA programs as examples of the American genius for improvisation in an emergency—but emergency is only another name for neglect of foresight and timely planning. Who will deny that if a program of public works to cost half of our ultimate expenditures for work relief had been developed in time of prosperity and that amount had been appropriated at the onset of the depression the depression would have been ameliorated, millions would have been spared impoverishment and many more public works increasing our standard of living would have been provided?

We have learned our lesson in some degree. Also our task is easier. In 1933 we were in the depths of the depression. Now we are in a period approaching full employment. Planning public works is far advanced over its condition then. The Federal Works Agency, the successor of PWA and WPA and heir to their experience, has the techniques. An appropriation to it would find it ready.

Let me recount briefly some of the items of preparation for a comprehensive program of post-war public works, now complete or in process.

As a result of the old PWA program almost all of the States have enacted revenue bond legislation and bond buyers have learned to accept that form of security. The capacity of State agencies to finance their public works has been greatly enlarged. In cooperation with the Local Public Works Programming Office, set up under the sponsorship of this

Agency and the National Resources Planning Board, eight States have prepared six-year programs and seven additional States have them under way. About 75 cities have completed such programs and some 25 more are close to completion.

The preparation of the Federal construction agencies is now far advanced over what it was in 1933. Since June, 1940, they have been required to prepare and keep up to date, with schedules of priorities and estimates of cost, six-year programs of public works. The total estimated cost of construction recommended by the President to Congress for fiscal year 1943 was over six billions. The major items were national defense construction of a total of 4.6 billions; power development, 188 millions; flood control, 1.6 billions and irrigation, 90 millions. The war emergency changed the situation so that some non-defense projects were deferred.

The Federal Housing Administration, having an enormous stake in urban real estate, has made studies of the alarming and progressive decadence of large areas of our cities, and attributes it to lack of seasonable city planning and of adequate public control of land use. FHA urges that local planning agencies be strengthened and their plans legislated into effect. It also suggests that cities create "urban realty corporations" to acquire continuously tax delinquent, blighted and other appropriate areas to be utilized for parks, streets, housing or for other facilities according to the city plan. The States of New York, Illinois, Michigan and Kentucky recently have provided for redevelopment corporations, to acquire and redevelop blighted areas pursuant to municipal plans. Such projects might be included in a comprehensive program of public works.

The Public Roads Administration has also studied municipal decadence. It is convinced, and has gone far in persuading Congress, that an effective remedy would be to carry wide avenues of the Federal-State highway system into and through blighted urban districts and the hearts of our cities, thereby furnishing those districts with light, air and means of access, lack of which has caused their decay. I agree, provided that this construction be in conformity with the local plan for the city.

Congress has enacted legislation of great importance in the preparation of a public works program. The Defense Highway Act of 1941 for the first time enables the Commissioner of Public Roads to advance funds to local authorities to acquire rights-of-way for projects authorized by the Act. These include extensions to the strategic network of highways, which may include city streets. He is also given $10,000,000 to finance the federal share of the cost of advance engineering plans and surveys. This Act contains another new provision which I believe will produce large economies in money and time. It authorizes the Federal Works Administrator to acquire forthwith by purchase or eminent domain any lands required for projects authorized by the Act and to convey such lands to the highway department of the State or to its political subdivision upon its promise to maintain the improvement. This means that we need no longer wait in constructing such projects for the slow processes of eminent domain of the States. The laws of most of them require that ascertainment by a court of the value of land to be taken must precede its occupancy and use by public authority. Under Federal law the land may be used forthwith upon filing a certificate of taking in the Federal court. Its finding of the value follows in due course.

I may say in passing that the plan of cooperation in highway construction established by the Federal Aid Road Act in 1916 has been one of the clearest landmarks of the long progress toward better relations of the Federal government and the States. The splendid results in upbuilding of the nation's major highway system that have been achieved under this legislation are largely attributable to the remarkably effective cooperation that has at all times distinguished the activities of the Public Roads Administration and the State highway departments.

In no small measure the success of the joint administration has been aided by the opportunities provided by the annual meetings of this Association for deliberation upon working policies and procedures, and by the continuously intelligent action of its standing committees.

But, members of this Association, I am sure, will agree that the establishment and uninterrupted continuance of these unusually effective inter-governmental relations have been due mainly to the patient guidance and wise counsel of the one man who, for twenty-three years, has headed the agency charged with the administration of the Federal government's part in the joint undertakings. and who is with us today, I am happy to say, as Commissioner of the Public Roads Administration, Thomas H. MacDonald, a great engineer and outstanding administrator of public affairs.

Holding these views, as I do, you will understand that, in the adjustments essential to a closer coordination of the public works operations of the Federal Government, there is no purpose to alter in any way the relationship between the State highway departments and the Public Roads Administration or the existing channels of that relationship through the field organization of the Public Roads Administration.

Highways are the oldest and, in my opinion, still the most fundamental and necessary kind of public works. National unity, prosperity in peace and victory in war are largely dependent upon the adequacy of the transportation system. The Roman and Persion empires had long lives because of their excellent highways. Napoleon's victories were due in part to the highways he caused to be constructed, and yet his ultimate downfall may have been partly due to the fact that his roads did not reach many of the areas in which he had to fight.

Our highway system, rural and urban, still in great part designed in horse and buggy days, has lagged far behind the nation's needs. Relocation of population and industries, economic changes, the development of facilities for air transport, have made much of the system obsolete. Redesign and construction with regard to regional, State and local master plans, is necessary. Highways, of course, are not ends in themselves but means to ends. These ends are set out in such master plans. It is also clear that emphasis on the development of the Federal-State Highway System should be transferred from the country to cities, since it is in urban areas that congestion exists.

Relief of urban congestion is dependent upon increased facility in acquiring the necessary land. The powers of the Federal Works Administrator under the Defense Highway Act will help greatly. Title II of the N. I. R. A. gave the Public Works Administrator power to acquire by purchase or by eminent domain land for any project included in the comprehensive program of public works there provided for. Under the Lanham Act the Federal Works Administrator may so acquire land for war public works and may also dispose of it to the appropriate agency of the State. No good reason appears why the same powers should not be given the Administrator of a post-war program of public works. He could then acquire the land, construct the improvement and in proper cases convey it to the appropriate agency of the State upon its promise to maintain. If Congress confers these powers on the Administrator the program will be expedited and its cost substantially reduced. State rights would not be infringed as the arrangement would be with the consent of the State. Few States, in my opinion, would refuse consent. Congress may also confer on the Administrator the power to take and dispose of land marginal to the improvement; that is, adjacent land which he finds is so connected with the improvement that public control of the use of this adjacent land is necessary to the public's enjoyment of the improvement or to the accomplishment of the city plan. In many cases the disposition of the adjoining land with proper controls of use will substantially reduce in the long run the cost of the improvement. Such powers may be so utilized as to contribute to the arrest of the blighting of our cities.

The work of the National Resources Planning Board has contributed and will continue to contribute indispensable aid in the preparation of a nation-wide program of public works. The Board has compiled and published reports on the projects of the Federal construction agencies. It has cooperated with the States in setting up regional, State and local planning boards, many of which have developed plans. The Board also has worked out and published studies on the techniques of planning. Its connections with local agencies also will be of great value in establishing the federal-local cooperation necessary for success in this field.

In sum, many of the studies and plans which must precede the preparation of a comprehensive program are made or in process. A substantial part of the federal and local legislation necessary has been adopted. But additional legislation by Congress, State legislatures and city councils is desirable.

In the Federal Works Agency we are giving much thought to the possibilities of further legislation to facilitate the preparation of a comprehensive program of federal and non-federal public works for execution when and as Congress may determine. Power to cooperate with local programming agencies, we feel, should be included. We believe there is yet time to develop a program which will promote the conversion of the nation from war to peace with a minimum of shock, reduce the danger of economic collapse, aid in sustaining full employment and provide useful public works which will raise our standard of living and enhance the welfare of all the people.

15,000 Sq. Yd. Concrete Daily at Southern Airport[1]

AT a large mid-southern airfield maximum speed and continuity of concrete paving operations were insured through the wet spring months by good paver management and by capitalizing the stone base as a working mat. Three 5,500-ft. runways with connecting taxiways, aprons, and ramps to 5 hangers were placed and the entire job, including 3,000,000 cu. yd. of material removal in grading, was practically completed between February 9 and June 1.

Excavation, planned in such a way as to permit fast follow-up on the pavers, was rushed in 3 shifts using scrapers or shovels and trucks and depending on the haul. Intermittent rainy periods were offset by showings of as high as 350,000 cu. yd. in good weeks.

Notes on Paving Procedure

Six pavers handled the job. Two outfits, consisting of a 34-E dual-drum working alone and two 34-E single-drums teamed up on each side of the forms paved main runways from one batching plant. Two other outfits, comprising a pair of 27-E pavers also in main runways and a 27-E "clean-up" mixer for ramps, taxiways, etc., were served by another plant. The five runway pavers operated two 8-hour shifts; the clean-up unit, one. With a 10 per cent overload this outfit averaged approximately 15,000 sq. yd. or slightly over a mile of 25-ft. runway strip per paving day.

The value of crushed stone as a working mat as well as a pavement base was demonstrated by the fact that through 60 spring days pavers worked every day—even on rainy days when grading was halted by muddy conditions. The procedure was to place crushed limestone in two courses. First a 3-in. layer was spread over the entire 150-ft. runway width. Then when forms were set a second layer was placed, graduated up to 3 in. additional thickness to conform to the subgrade cross-section for the 10-7-10 slab. Stone was crusher-run, well graded up to 1½ in. max., the top course having about 5 per cent binder dust.

The project was under the supervision of a district office of the U. S. Corps of Engineers.

[1] Reprinted with permission from December, 1942, issue of *Roads and Streets.*

Post-War Transportation

PRESIDENT ROOSEVELT has sent to Congress a National Resources Planning Board report recommending major modernization of the country's transportation facilities after the war under the direction of a new Federal agency, into which would be consolidated all present Government transportation development agencies and which would be responsible for consolidating railroads and other transportation systems, constructing terminals, coordinating systems and encouraging new forms of transport. The report, fifth in a series of a post-war planning studies and drawn up by a committee headed by Owen D. Young, also included these following other recommendations: (1) Government planning to establish air travel "as a major and integral part of our future transportation policy"; (2) Federal financing of railroad modernization and improvement as a pub-

(*Continued on page 17*)

STONE SPREAD ACROSS ENTIRE 150-FT. RUNWAY WIDTH HELPED PAVERS GOING EVEN IN WEATHER TOO WET FOR EARTH MOVING.

THE FINISHED RUNWAY LOOKS LIKE THIS

Commissioner MacDonald Reports on Alcan Highway

MOBILE forces of more than 6,000 civilian workers were moved into Canada and Alaska by plane, truck, boat and railroad to join with U. S. Army engineers in cutting and bulldozing the Alcan road through the wilderness of the Northwest with unparalleled speed, Commissioner Thomas H. MacDonald of the Public Roads Administration announced recently.

Returning from Alaska after a month of directing and inspecting work of the Public Roads Administration on the trail and highway job, Commissioner MacDonald reported to Major General Philip B. Fleming, Federal Works Administrator, that the civilian force was the largest ever put to work on a single highway job and, he believed, the most effective. This force worked at all times in closest cooperation with the Army Engineers who were in charge of the undertaking, Mr. MacDonald said.

With it into the wilderness went the trail and highway building equipment of 52 Canadian and American contractors, supplemented by hundreds of tractors, power shovels, portable repair shops and electric plants hastily assembled from Civilian Conservation Corps camps in many States.

The Public Roads Administration, a constituent of the Federal Works Agency, began assembling the big civilian force, quietly, on March 6, when it was requested by the War Department to cooperate in the location and construction of a permanent, modern road.

Under an agreement with the Department the Roads Administration undertook to make reconnaissance and location surveys, prepare plans, award contracts or otherwise arrange for and supervise construction. All steps were planned in close cooperation with the Chief of Engineers of the War Department and were subject to his approval.

Under the plan agreed upon, the War Department undertook construction of a truck-trail road following as closely as practicable the route selected for the permanent road after reconnaissance surveys.

Launching of such a large project and completing the many steps preliminary to construction required an all-out effort on the part of Public Roads engineers. A headquarters office for the project was established at Seattle, Washington, and field offices were located at several points along the route. A force of 500 engineers and engineering aids was rushed into the field to make surveys and supervise the work of contractors.

For quick enlargement of the supervisory staff, contracts were negotiated with four well-known engineering firms to act as project managers. These firms were C. F. Lytle Company and Green Construction Company (organized as a single firm) of Sioux City, Iowa; Dowell Construction Company of Seattle, Washington; R. Melville Smith Company of Toronto, Canada; and Okes Construction Company of St. Paul, Minnesota.

These contractors immediately recruited 52 construction contractors who, after approval of the individual contracts by the Public Roads Administration, began the movement of men and materials to the job. E. W. Elliott of Seattle, Washington, took a contract for movement of all equipment and the erection of shops, warehouse and other buildings.

A great quantity of equipment was transferred from the Civilian Conservation Corps to supplement the equipment owned by contractors. Among the major items were 300 tractors equipped as scrapers, bulldozers or trailbuilders, 1,000 trucks, 125 air compressors with drilling accessories, 55 power shovels, 200 electric light plants, 65 portable repair shops. Mixers, rollers, pumps and trailers were also supplied.

Approach to the job was by three main routes: (1) by rail via Edmonton, Canada, to Dawson Creek, the beginning of the project, (2) from Seattle via the inland water route to Skagway, thence by narrow-gauge railroad to Whitehorse and to the job, and (3) from Seattle by inland water route and across the Gulf of Alaska to Valdez and thence by highway to the job.

For water transportation the Public Roads Administration has obtained the use of 5 steamships, 1 motor ship, 5 yachts, 14 barges and 10 tugs. About 1,200 men were flown to the northern end of the project to establish living quarters, shops, warehouse and other essentials for operation.

Equipment for kitchens and living quarters came from Civilian Conservation Corps supplies.

Actual construction operations began at many

points along the route in May and June and have progressed continuously under maximum pressure. The original plan for the Army engineer forces to build a truck-trail road and the Public Roads Administration to follow with the building of a permanent highway on or near the truck trail was revised in August because of the necessity of opening the entire length of the route to truck travel at the earliest possible date.

The forces of the contractors have been given the job of placing a gravel or other type of surface on the entire length of the route and of maintaining it in condition for use. They are working with the Army forces in grading many sections of the road.

All major structures requiring special designs are being designed by the Public Roads Administration and constructed under its supervision. The Peace River, near the southern end of the project, is now crossed by ferry. For use during the winter a temporary timber trestle is being erected.

Workers are housed in buildings from over 40 Civilian Conservation Corps camps that have been dismantled, transported to the job and reassembled.

American and Canadian contractors have already brought to near completion the grading and surfacing of 102 miles of permanent road built to high modern standards. Seventy-seven miles of this work is on the south end of the project where it was not necessary to build a pioneer road. Army and contractors' forces have operated jointly to produce a satisfactory Army road for use during the coming winter. In this pooled operation, forces of the contractors graded and surfaced many miles of the road. On hundreds of additional miles they have followed behind Army engineer forces, widening the road and doing additional grading and surfacing. These operations cover a total of 1184 miles of the 1600-mile route.

Post-War Transportation

(*Continued from page 15*)

lic works program; (3) restoration of motor transport after the war "on a modern and efficient basis," with emphasis on express highways and off-street parking in urban areas; (4) Government planning for "economic consolidation" of operating railroads into a limited number of systems arranged along regional lines, but avoiding systems of excessive size; and (5) planning of terminals to serve all transportation systems.

Highway Incomes Can Stand Losses and Remain Above 10-Year Average

STATISTICIANS attempting to determine probable effects of restricted motor vehicle use on highway finance have figured out that gasoline tax collections in 1941 (an all-high year) had increased more than 85 per cent on a national average over 1932. During this 10-year period many states saw increases of more than 100 per cent in their gasoline tax yields.

Greatest gains were 162 per cent in Alabama, 154 per cent in Arkansas and South Carolina, 158 per cent in Louisiana, 151 per cent in Connecticut, 143 per cent in Mississippi, 134 per cent in West Virginia, 133 per cent in Oregon, 132 per cent in New Mexico and 130 per cent in Rhode Island.

These same mathematical wizards have figured out that the national average of state gasoline tax collections can decline 26 per cent below 1941 returns and still remain above the 1932-1941 10-year average. Samples of the higher percentage reductions which can be experienced before state gas tax receipts drop below the 10-year average include Alabama, 34 per cent; Connecticut, Rhode Island, Vermont and West Virginia, 32 per cent; Arkansas, Florida, Georgia, New Mexico, Oklahoma and Oregon, 30 per cent; Delaware, Idaho, and Tennessee, 29 per cent; Arizona, Kentucky, Maryland, North Dakota and Utah, 28 per cent; District of Columbia and Wyoming, 27 per cent.

Average reductions in state gasoline tax collections in the Eastern area, where rationing follows closely the mileage cut recommended by the Baruch report, are about 40 per cent.

Despite reduced income some states in the originally-rationed Eastern area are accumulating highway fund surpluses because of enforced curtailment of construction and maintenance work. Campaigns are already under way in many of these states to safeguard these war-time surpluses for post-war highway work.

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52 Vanderbilt Ave., New York City
KOTAL, the Waterproofing Agent for Aggregates that Improves Hot Mixes, Cold Mixes, Traveling Plant Mixes and Road Mixes of Bitumen

Kraft Bag Corporation
630 Fifth Ave., New York City
Multi-Wall and Heavy-Duty Paper Sacks, both Valve and Openmouth

Lima Locomotive Works, Inc.
Shovel and Crane Division
1108 Lima Trust Bldg., Lima, Ohio
Power Shovels, Draglines and Cranes

Link-Belt Co.
300 West Pershing Road, Chicago, Ill.
Complete Stone Preparation Plants. Conveyors, Elevators, Screens, Washing Equipment, Speed-o-Matic Shovels—Cranes—Draglines and Power Transmission Equipment

Ludlow-Saylor Wire Co.
Newstead Ave. & Wabash R. R., St. Louis, Mo.
Woven Wire Screens and Wire Cloth of Super-Loy, Manga-Loy and all commercial alloys and metals

Mack Manufacturing Corp.
34st St. & 48th Ave., Long Island City, N. Y.
Trucks, Truck-Tractors of All Types and Capacity, Gasoline or Diesel Power Optional

MANUFACTURERS' DIVISION of the NATIONAL CRUSHED STONE ASSOCIATION

Marion Steam Shovel Co.
Marion, Ohio
A Complete Line of Power Shovels, Draglines and Cranes

McLanahan & Stone Corp.
Hollidaysburg, Pa.

The National Supply Co., Superior Engine Division
1401 Sheridan Ave., Springfield, Ohio
Diesel Engine Equipment

Nordberg Mfg. Co.
Milwaukee. Wis.
Cone Crushers, Vibrating Screens, Diesel Engines, Steam Engines, Compressors, Mine Hoists, Underground Shovels, Track Maintenance Tools

Northern Blower Co.
65th St. South of Denison, Cleveland, Ohio
Dust Collecting Systems, Fans—Exhaust and Blowers

Northwest Engineering Co.
28 E. Jackson Blvd., Chicago, Ill.
Shovels, Cranes, Draglines, Pullshovels

Parsons Engineering Corp.
3599 E. 82d St., Cleveland, Ohio
Dust Collecting Systems: Fans, Hoods and Blow Piping

Pioneer Engineering Works, Inc.
1515 Central Avenue, Minneapolis, Minn.
Jaw and Roll Crushers, Vibrating and Revolving Screens, Scrubbers, Belt Conveyors, Traveling Grizzley Feeder

Pit and Quarry Publications
538 South Clark St., Chicago, Ill.
Pit and Quarry, Pit and Quarry Handbook, Pit and Quarry Directory, Concrete Manufacturer, Concrete Industries Yearbook

Robins Conveying Belt Co.
Passaic, N. J.
Belt Conveyors, Bucket Elevators, Gyrex and Vibrex Screens, Feeders, Design and Construction of Complete Plants

Rock Products
309 West Jackson Blvd., Chicago, Ill.

Ross Screen and Feeder Co.
19 Rector St., New York City
Ross Patent Chain Feeders for Feed Control of All Sizes Rock, Ores, Gravel, etc.

Screen Equipment Co.
9 Lafayette Ave., Buffalo, N. Y.
SECO Vibrating Screens

Simplicity Engineering Co.
Durand, Mich.
Simplicity Gyrating Screen, Simplicity D'centegrator, Simplicity D'watering Wheel

Smith Engineering Works
E. Capitol Drive at N. Holton Ave.,
Milwaukee, Wis.
Gyratory, Gyrasphere, Jaw and Roll Crushers, Vibrating and Rotary Screens, Gravel Washing and Sand Settling Equipment, Elevators and Conveyors, Feeders, Bin Gates, and Portable Crushing and Screening Plants

Stedman's Foundry & Machine Works
Aurora, Indiana
Stedman Impact-Type Selective Reduction Crushers

Stephens-Adamson Mfg. Co.
Aurora, Illinois
Complete Stone Preparation Plants, Conveying, Elevating, Screening, Transmission Equipment

W. O. & M. W. Talcott, Inc.
91 Sabin St., Providence, R. I.
Belt Fasteners, Belt Lacing, Conveyor Belt Fasteners, and Patch Fasteners

Taylor-Wharton Iron & Steel Co.
High Bridge, N. J.
Manganese and other Special Alloy Steel Castings

The Texas Co.
135 E. 42nd St., New York City
Asphalts, Lubricating and Fuel Oils

The Thew Shovel Co.
Lorain, Ohio
Power Shovels, Cranes, Crawler Cranes, Locomotive Cranes, Draglines. Diesel Electric, Gasoline. 3/8 to 2-1/2 cu. yd. capacities

The Traylor Engineering & Mfg. Co.
Allentown, Pa.
Stone Crushing, Gravel, Lime and Cement Machinery

Trojan Powder Co.
17 N. 7th St., Allentown, Pa.
Explosives and Blasting Supplies

The W. S. Tyler Co.
3615 Superior Ave., N. E., Cleveland, Ohio
Wire Screens, Screening Machinery, Scrubbers, Testing Sieves and Dryers

SCRAPE for SCRAP!

Dormant scrap is defined as obsolete machinery, tools, equipment, dies, jigs, fixtures, etc., which are incapable of current or immediate future use in the *war production effort* because they are broken, worn out, irreparable, dismantled or in need of *unavailable* parts necessary to practical re-employment.

If it hasn't been used for three months, and if someone can't prove that it's going to be used in the next three—find a use for it—or "scrap" it!

"DO IT NOW!"